Code 582

Flight Software Branch

FSW SOFTWARE REQUIREMENTS REVIEW (SRR) STANDARD

Flight Software Branch – Code 582

Version 1.2 – 02/17/06

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Goddard Space Flight Center

Greenbelt, Maryland

National Aeronautics and
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FORWARD AND UPDATE HISTORY

This standard describes the presentation requirements for a Flight Software (FSW) Requirements Review (SRR).

Version	Date	Description	Affected Pages
1.0	02/24/04	Final for baselining	All
1.1	04/19/04	DCR #70 - In Section 3 (Required Presentation Contents) the structure is wrong after "CANDIDATE FSW REQUIREMENTS TOPIC ORGANIZATIONS" DCR #59 – Appendix A (Checklist) added.	P15 – 17 Appendix A
1.2	02/17/06	DCR #107 - Appendix A (Checklist) removed.	Appendix A

CONTENTS

1 INTRODUCTION

1.1 PURPOSE & APPLICABILITY

The intent of this standard is to specify the Code 582 process and expected contents for conducting a well organized and beneficial Flight Software Requirements Review (SRR) that the development team, the branch (code 582), and the Project (codes 400/600/900, etc.) can "buy-into" and approve. The requirements and recommendations herein represent the "best practices" associated with some our most successful software review efforts previously given by branch personnel as well as presentations by out-of-house software teams. This standard also contains lessons learned from mistakes experienced in the past. As with any of the Code 582 process standards, all flight software team leads are expected to implement the standards contained within this document – with the recognition that the branch anticipates that updates and improvements will be appropriate and should be proposed.

The SRR should be regarded as a tool to aid the development team in flushing out key functional and performance requirements associated with a spacecraft and/or instrument early in the development life cycle. Quite often systems engineering is unable to decide on key requirements that might be drivers to the software design. The strategic scheduling of the SRR provides a mechanism to document and track requirements issues at a high-level of project visibility through the Requests For Action (RFA).

The intent of the FSW SRR is to ensure that systems engineering, the FSW development and test teams, other engineering discipline subsystem leads, and flight operations personnel all understand and agree on the correctness and completeness of the requirements to be implemented.

A second purpose of the SRR is to assess the technical feasibility of the requirements set, i.e., whether the FSW designer can postulate a design (or a set of design alternatives) that will satisfy the requirements within the characteristics of available flight hardware resources.

Last, but not least, the SRR provides a forum to assess the requirements set for compatibility with the mission development schedule, funding, and other Project resources.

1.2 APPLICABLE DOCUMENTS

The documents listed below provide direct insight into flight software development activities that should have occurred prior to the SRR and what will be expected at the next major FSW review.

- FSW Requirements Document Standard
- FSW Requirements Document Inspection Standard
- FSW Request For Action Form
- FSW Preliminary Design Review (PDR) Standard

Some of the standards referenced above had not been baselined at the time of publication of this document. Flight Software Branch baselined standards are available at:

http://fsw.gsfc.nasa.gov/internal/StandardsBaselined.cfm

1.3 DOCUMENT ORGANIZATION

Section 1 provides the purpose and benefits of conducting a Flight Software Requirements Review. It lists related configured branch documentation that is to be used when preparing for the review.

Section 2 provides guidelines for scheduling the SRR in terms of Project and FSW team milestones, plus requirements for the preparation, presentation, and post-review activities.

Section 3 provides the organization and content to be implemented at the SRR.

2 PREREQUISITES, PREPARATION, AND POST-REVIEW ACTIVITIES

2.1 PREREQUISITES

The FSW SRR is nominally to be scheduled approximately 2 months following the relevant spacecraft or instrument Project-level SRR. Experience has demonstrated numerous times that preparation of a FSW review prior to the corresponding Project-level review is problematic due to the rapid changes in flight hardware team decisions as they become more and more aware of the overall nature and details of the intended spacecraft/instrument package and operations concepts. Many technical decisions of significance to the FSW requirements will not be resolved until the mission review -- which drives collaborative decisions. Since the FSW requirements are driven from many flight hardware subsystem elements in addition to the science plans, the value of waiting until after the complete package is formally presented is tremendous. Preparation of a FSW review prior to the corresponding mission review results in immature presentation of FSW requirements, many questions at the review that are not in the realm of the FSW team to answer, and many actions from the review that create additional work for the team leads. Since the level of FSW content at the Project-level SRR tends to be rather high level and programmatic, there is no loss of substance at the Project-level SRR when the detailed FSW requirements review follows.

FSW team documentation that is prerequisite to the scheduling of the FSW SRR includes:

- FSW Product Plan — required to have been baselined or minimally signed by the appropriate Code 582 branch management representative
- FSW Test Plan — required to have been baselined or minimally signed by the appropriate Code 582 branch management representative
- FSW Requirements Document — must be at a high-level of maturity – although known missing requirements are to be expected. Appropriate subsystem leads and systems engineering should have reviewed and commented on previous drafts of the document.

At least one Code 582 branch management-led walk-through of the FSW Requirements Document has occurred and the recommendations from such have been incorporated.

Additional prerequisites to scheduling the SRR have to do with the availability of critical technical specialists who are key to knowing the full set of requirements on the FSW; the completion of one or more dry runs of the SRR with the FSW Branch; and the distribution of materials to the SRR panel members such that it is reasonable to expect that they could have had time to preview the materials prior to the SRR itself. See 2.2, 2.3 and 2.4 below.

2.2 REVIEW PANEL

Select an independent review panel minimally consisting of:

- Review Chairperson - a senior FSW Systems Engineer not involved with the project (controls the review, collects the RFAs, attendance list)
- Spacecraft or Instrument Systems Engineer
- One or more experienced flight software lead engineers not assigned to this project
- The Mission Director or Flight Operations Team Lead
- An independent non-GSFC reviewer – e.g., from APL
- Additional panel members as desired by the Project and the FSW team.

The following Project personnel are crucial to the success of the review. For most reviews, they are the authorities for a significant percentage of the requirements; hence their attendance is required. The review should be scheduled around their availability:

- Spacecraft or Instrument Manager/Principle Investigator
- Spacecraft or instrument discipline subsystem leads or their representatives as appropriate (ie; GN&C lead, PSE lead, C&DH lead, etc.) Their attendance is only required when you are covering the requirements associated with their subsystem.

The following Project personnel should be invited if currently assigned to the Project; however, their attendance is not mandatory:

- FSW On-orbit Sustaining Engineering Team representative
- Flight Operations Team representatives
- Project's Code 300 SQA representative
- WVA IV&V representative

Each member of the FSW development and test teams should be encouraged to attend since each will benefit from the experience and discussions.

2.3 DRY RUNS

The first SRR dry run is to be scheduled at least 2 weeks (ideally 4 weeks) prior to the review date. Since second and third dry-runs are not unusual, and the routine team progress must be satisfied, the earlier dry runs tend to be more productive and valuable to the team leads. A first dry run that represents more intent rather than content (on prepared slides) is encouraged in order to avoid major rework.

For this critical step in the over-all preparation process, perform the following:

Attendees:

- Invite all members of the branch management team, and get a commitment from at least one of them to attend the dry-run.
- Include one senior member of the branch who is unfamiliar with your Project, but has extensive experience with the same application (ie, a spacecraft or an instrument).
- After the initial dry-run, include selected Project representation as desired.
- Include FSW team members

Walk through the draft slides and discuss each slide as intended to be presented at the review. To the extent reasonable, use key members of your team as presenters.

Use the 3 minute per slide rule when estimating the time required for the review

2.4 REVIEW MATERIALS

Distribute the SRR review materials and other relevant available documentation 3-7 working days before the day of the review to all panel members and to all branch management team members:

- FSW Requirements Document(s) Required
- SRR Presentation Package Required

- Interface Requirements Documents (IRDs) Optional
- Interface Control Documents (ICDs) Optional
- FSW Test Plan Optional

2.5 REVIEW CONDUCT AND GROUND RULES

TBS

2.6 POST-REVIEW ACTIVITY

After the SRR, the RFAs are to be reviewed, with the following nominal practices:

- If an RFA is determined to be inappropriate to the nature of the SRR by both the Panel Chair and the FSW team lead, then the RFA may be rejected with the stipulation that the Panel Chair will recommend another target audience for the RFA and will offer to forward the RFA to that person/group. Each rejected RFA remains part of the record of the SRR with the resolution noting the forwarding action(s).
- If RFAs appear to be redundant with each other, then the RFAs may be combined into a single RFA under the following circumstances only:
    - All RFA authors of the apparently redundant RFAs are notified of the recommended combined wording of the RFA in which their RFA is intended. Explicit agreement that the new RFA wording captures the full intent of each author's submission is required prior to combining RFAs.
    - All original RFA authors must be recorded and tracked as authors of the combined RFA.
    - Since the combined RFA will have been confirmed to meet the full intent of the original RFA submission, the original RFA does not become part of the record of the SRR.
- If an RFA is not solvable by the next FSW review, ...TBS

The Panel Chair or the FSW team lead is to provide a full list of RFAs and the attendance list to all panel members and key personnel within one to two weeks (while it's still fresh on everyone's mind). Prior to distribution, the following must be accomplished:

- Make sure that all RFAs have an assignee responsible for providing the final resolution to the RFA.
- Indicate a proposed due date to close the RFA (if possible).
- For those RFAs that you assign to your team and plan to accommodate, state so in the initial distribution of the RFAs.
- Post both the Review Package and the RFAs on the FSW team's website.
- Track each RFA to closure. You will have to report on the status of these RFAs at the next major FSW review (e.g., at the FSW PDR) with the plan that all should be closed at that time if possible.

3 REQUIRED PRESENTATION CONTENTS

INTRODUCTION (~9 CHARTS)

Scope (1 chart)

Explain the scope of this review in terms of the technical content to be addressed and those tangential topics that are not part of this review. The intent is to make it clear that issues, in areas other than the identified topic(s), are not the responsibility of this technical team or review panel. For example: If the topic of this review is spacecraft FSW, then the scope may include C&DH, GN&C and power; and it may not include ground software, GPS software, firmware within an electromechanical device, etc.

This clarification up-front is likely to avoid confusion during review discussions.

FSW SRR Goals (1 chart)

- To confirm the correctness and completeness of the requirements to be implemented.
- To flush out and explicitly identify functional and performance requirements which are not clearly understood or available.
- (Note to the audience that this goal will be met via submission of requests-for-action (RFAs) and the resulting follow-through. The RFAs essentially become liens against the FSW requirements documentation.)
- To assess the requirements set for compatibility with the mission development schedule, funding, and other Project resources.

Successful completion of the SRR determines that the requirements, as documented and updated via the forthcoming RFA decisions, form a satisfactory foundation for FSW implementation and test.

Review Panel Introduction (1 chart)

Provide the names and specialty areas of each person on the review panel.

Introduce the Panel Chair.

Ask the Panel Chair to introduce the panel members, the rules during the review, the RFA forms and who will collect the RFA forms.

This is probably better explained, than provided on a chart: All RFAs are to be submitted to the Panel Chair who will work with the FSW team leads for proper assignment of the actions. The panel will document all RFAs and distribute the full SRR list to all SRR attendees. The panel will review all RFA responses and make a recommendation as to whether the SRR has satisfied its criteria for success (as identified on the previous slide – were the goals met?). The Panel Chair will prepare and distribute an SRR Summary Report to the Project and the FSW Branch. If a Delta SRR is recommended, that Delta SRR must be completed prior to the next major FSW review (in this case the FSW PDR).

Initiate a signature sheet for each attendee to sign.

Agenda (1 chart)

Provide anticipated durations for each main topic. Anticipate 3 minutes per slide.

Nominal times for a typical spacecraft FSW development are shown.

Do not try to accomplish this review in less than a full day, and do not avoid breaks during the review. If it appears that a full day may be optimistic, reserve the conference room, and schedule the review, into the next day to accommodate a tired audience and more review material.

- Introduction 25 minutes
- FSW Process Overview 45 minutes
- FSW Context 35 minutes
- FSW Design Requirements <10 minutes

Finish the above portion within 2 hours of SRR start.

- FSW Functional and Performance Requirements 3 minutes/slide
- FSW Resource Utilization Requirements 10 minutes
- FSW Qualification Requirements 30 minutes
- Risks and Issues 30 minutes

Mission Introduction (4-5 charts total)

- Present high-level science goals. Introduce the instruments plus organizations providing major mission elements.
- Provide design life goals, launch vehicle and date, end-of-life strategy.
- Introduce the orbit & pointing characteristics.
- Using a very high-level mission diagram, show flight-to-ground interfaces.

This is not the place to describe the flight hardware configuration or operations concept beyond Project level requirements. This Overview should be a very few charts, just enough to provide the high-level introduction of the mission science characteristics and mission design objectives. See FSW Context section for the substantive operations discussion.

RFA Status

(from any previous Reviews, i.e., System Concept, Confirmation, etc.)

Identify the number of RFAs from previous reviews. Describe each RFA that is still open (one bullet for each) with projected closure dates and the reason(s) that the RFA remains open. Identify where closed

RFA responses may be found (e.g., web address).

FSW PROCESS OVERVIEW (~12 CHARTS)

The intent of this section is to introduce the FSW requirements development and control processes and where the process to be used by the FSW team during development and test can be found.

Project Organization

Highlight where the FSW team fits within the Project organization

FSW Team Status

- FSW team organization
- FSW Team Staff & Budget
- External Dependencies

FSW Team Process Documentation

How the FSW team will accomplish the FSW development and test efforts

- FSW Product Plan provide document number and baseline date
- FSW CM Plan provide document number and baseline date
- FSW Test Plan provide document number and baseline date

FSW Requirements Development Process (4 charts)

How the FSW team will accomplish the FSW development and test efforts

- FSW Requirements Tree -- Provide a FSW-specific document tree showing each parent document as a source document to the FSW system. Highlight each FSW requirements document under review today. Provide document number and baseline date of each. Typical driving documents include:
  - Mission Requirements
  - Spacecraft and/or Instrument Requirements
  - Spacecraft and/or Instrument Subsystem Requirements (Project Level)
  - Operations Concept

It may be useful to reference the mission document tree from which the detailed FSW requirements document tree was derived, but this is typically not a good place to present the entire parent requirements document tree. The intent of the FSW-specific parent document tree is to be explicitly clear about the parent documents that have actually been used by this team. By limiting the context on the chart, there is more chance that the audience will be able to detect if any parent document is missing and where FSW driving requirements belong if new driving requirements are identified during the review.

- List each IRD, ICD, hardware specification, algorithms document, etc. which has an impact on the FSW requirements. Provide status, document number and baseline date (often anticipated) of each.
- FSW Requirements Document(s) Status - Provide status, document number and anticipated baseline date for each
- Provide a brief sample of FSW requirements traceability matrix from/to parent documents (could be provided at end of presentation as backup or appendix)

FSW Requirements Control Approach (2 charts)

- Provide the diagram of the FSW Requirements Control Process (from the FSW Product Plan).
- FSW Requirements Control Highlights:
  - Controlled via the FSW team change control system through launch (identify the tool being used)
  - FSW change requests will be submitted to the Project for approval:
    - if implementation could impact FSW schedule or cost
    - if implementation could impact another mission subsystem
    - following FSW Acceptance Test

FSW Schedule

One page FSW schedule showing key Project milestones, FSW-dependent deliveries from external organizations, FSW milestones, etc. (from the FSW Product Plan, updated as necessary).

FSW CONTEXT (13-15 CHARTS)

This section is key to the review because it sets the stage for the full set of requirements that the FSW system must accommodate. The intent of this portion of the presentation is to present the different FSW requirements' drivers from several tangible mission perspectives – i.e., flight operations, the flight hardware environment and the software interfaces environment.

Mission Operations Context (4-5 charts)

The intent is to introduce the full range of responsibilities of the FSW so that the audience will recognize

the need for FSW requirements that may be outside the expertise of hardware subsystem experts.

- Science and Orbit drivers on the FSW system, e.g.:
  - Science control modes, spacecraft/science instrument interfaces if relevant
  - Preplanned onboard science commanding, required science event handling, etc.
  - If science mechanisms, detectors, etc. require special protection or handling by FSW, mention the general responsibilities.
  - Calibration scenarios (e.g., occasionally point to moon and do special onboard processing – if none are known, state that expectation)
  - Maintain orbit, if relevant
- Special Mission Requirements (probably not relevant to instrument FSW)
  - Support Launch and in-orbit insertion
  - Support End-of-life
- Command and Data Handling drivers
  - Provide a comprehensive graphic showing the flight data system, FSW elements, data flows, data rates, data storage and the ground system.
  - Explain any special need for onboard autonomy and/or onboard data handling related to the ground/flight interface (e.g., lights-out operations), data record and playback, etc.
- Generic drivers on FSW requirements (1 chart)
  The intent here is to simply introduce all additional areas of requirement drivers that resulted in requirements on the FSW system. Avoid lengthy explanations at this point suggesting that questions be held until the topics come up later – provide a simple example if necessary and move on.
  - Protect all flight hardware (e.g., anomaly failure detection and handling)
  - Provide for remote troubleshooting of flight hardware and FSW (e.g., telemetry filtering)
  - Provide remote insight into FSW behavior (e.g, CPU mode transition logs)
  - Provide capabilities to maintain FSW code
  - Provide capabilities to update FSW data post-launch
  - Support incremental integration and test of FSW components (e.g., generate FSW application connections to the FSW system upon application start-up)
  - Support less-than-the-full complement of flight hardware during I&T (e.g., detect connected hardware elements during CPU start-up)
  - Provide visibility into FSW behavior that will aid FSW developers and testers during FSW integration and test activities (e.g., extra telemetry points & event messages)
- Decisions and Assumptions
  Provide assumptions specifically related to the overall science and mission operations concepts that have FSW requirements implications (e.g., the FSW is required to notify each science instrument of Safehold entry so that each instrument can do its own safing process.)

Flight Hardware Context (3 charts)

The intent is to clearly identify the flight hardware environment that the FSW will need to manage. Be sure to emphasize that the role of the FSW is to enable the full set of flight hardware to execute as an integrated science system.

- Provide a graphic block diagram of relevant flight system hardware -- including specific processors, buses, sensors, actuators, data storage, communications, power, science elements
  - Represent each redundant flight hardware element on the diagram
  - Locate major software functional elements (e.g., C&DH, GN&C, power, instrument) on the diagram
  - Identify data communications paths among the hardware elements and the ground.
- Provide types of flight processor, types of memory and data storage, sizes, rates, etc. for each data system item.
- Decisions and Assumptions
  Provide assumptions that drive FSW requirements and are related to flight hardware decisions. This might include the radhard nature of the flight hardware that eliminates the need to check flight memory for single event upsets. Or the intended redundancy management philosophy that drives whether the FSW is required to autonomously transition to redundant hardware in the event of an anomaly on the primary hardware items.

Flight Software Context (3-5 charts)

The intent is to clearly identify the relationship of the software system under review with other software elements.

- Provide a block diagram showing the full set of relevant software products (loadable images) that make up the mission system, emphasizing and highlighting the FSW under review and its interfaces to other mission software (both flight and ground). This is intended to be a simple software block diagram probably representing FSW on multiple flight processors and including the ground as a software system interface to the FSW. The diagram is to be at the level of the FSW ICDs.
- Decisions and Assumptions
  Provide assumptions that drive FSW requirements and are related to the allocation of requirements among the various software products (e.g., science data compression will be handled by the xxx software), or decisions about the interfaces between software products (e.g., CCSDS or IP will be used), etc.

FSW Design Decisions (2 charts)

The intent here is to state that some functional requirements are the result of FSW re-use decisions that have already been made.

- Identify the FSW requirement areas that are fully or partially satisfied by the FSW reuse strategy. Explain the heritage nature of the FSW to be reused (e.g., x years of on-orbit experience on the y mission). This could include capabilities such as: stored command handling as implemented on mission x, onboard telemetry monitoring and response, flight memory load

and dump support, etc. Mention that details of these requirements will be provided along with the rest of the mission FSW requirements during the SRR so that the audience may evaluate their applicability to this mission.

- Justify the FSW reuse decision (e.g., save costs, schedule, team experience, a good architecture for incorporating the mission unique functionality, performance or memory characteristics, etc.).

Current belief is that it is inappropriate to provide a software architecture diagram at the SRR. Experience has shown that representing the FSW at the lower level of detail (e.g., a 'software bus' chart) moves the focus of the review to design and away from the functional requirement discussions. The goal of the SRR is to get agreement on the requirements and the architecture characteristics are more appropriately introduced at the PDR.

FSW FUNCTIONAL & PERFORMANCE REQUIREMENTS

This section provides the functional and performance requirements as they are defined in the FSW Requirements Document(s) except that the wording is to be paraphrased such that the intent of the requirements is easily communicated to an audience.

Organize the requirements by flight CPU image.

If requirements are common across multiple CPU, address those specific requirements once with reference to the unique character of the requirements for particular CPU. It may be useful to present these requirements after the application specific requirements for all relevant CPU.

Each requirements topic is to begin with a verb.

Each requirements topic should attempt to address the overall mission need for the requirements (see Software Context section).

Provide a meaningful flow to the requirements presentation by ordering the requirements topics from 'start-up' through the increasing capabilities that enable full FSW operations. Ideally, use the organization of the FSW Requirements Document to define the requirements for each major functional area of the flight software. (If a FSW Requirements document is not organized in a meaningful flow of topics, then diverge from the document organization as appropriate.)

Use high-level functional phrases (e.g, Accept, Validate, Process, Perform, …) and lower-level bullets that summarize the documented requirements. The object is to communicate the requirements in a presentation format that encourages the audience to assess the completeness and accuracy of the FSW Requirements Document based on the phrases being presented.

Use graphics to describe requirements areas (e.g., CPU mode transitions, control mode transitions, timing) where appropriate.

Use structure English, Use diagrams, etc. to describe requirements when appropriate.

Address in detail those requirements that are considered especially critical and/or controversial.

Identify, within the charts, all FSW requirements requiring clarification or additional information. The use of TBDs or other ‘yet to be resolved’ notation is to be used for purposes of highlighting decisions yet to be

made. All lingering requirements decisions are to be summarized at the end of this presentation (as risks or issues).

In every case, make the charts easily understandable by non-software engineers. Avoid highly busy and complex FSW team-unique charts. The object is to communicate to a variety of engineers and science specialists and to encourage them to detect requirements omissions and errors. Simple, communicative charts are best.

Each major FSW requirements topic should have 5 subtopics:

- Functional Requirements (with performance reqmts. when relevant and missing requirements maturity identified)
- Error Detection and Handling
- Command requirements (list functional commands)
- Critical Telemetry that are essential to the nature of the requirements
- Asynchronous Event requirements (list)
- Risks and Mitigation Strategies:
    - Introduce any prototypes, simulations or other risk mitigating techniques that indicate FSW requirements feasibility.
    - Indicate how the prototype results, trade analyses, studies, etc. can be accessed.

It is very important to identify weak, immature and missing requirements during the SRR. The FSW team should have very good knowledge of 'holes' in their end-to-end requirements set. Being open and direct about these absences and 'guesses' will provide credibility to the presenters. This said, it is not appropriate to say more than once that table-driven launch criteria are not known at this time.

Sample Requirements Description - FSW System Start-up

(sample requirements only)

Respond to Main Processor Power-on (Boot-up)

- Functional Requirements
    - Initialize …
    - Select FSW image to execute from (EEPROM, RAM, …)
    - Perform xxx hardware and I/0 diagnostics
    - Initialize RAM -- Copy from EEPROM to RAM, verify copy was successful
    - Initialize all FSW applications and verify successful initialization via receipt of housekeeping data from each application task
    - Accept data input from all devices
    - Generate and downlink raw hardware and all available software telemetry
    - Execute RTCS #1 (null default, or specialized, start-up sequence established by ground)

- Activate each other CPU and initiate xxx handshaking
- Ensure that every start-up results in the same initialization characteristics.
- Wait for ground commands

- Error Detection and Handling
  - Identify errors to be detected during boot-up and FSW responses to errors
- Relevant command requirements (any commands that can be sent during boot mode?)
- Critical telemetry requirements (different data rate during boot mode?)
- Asynchronous Event Requirements (boot mode events?)
- Risks and Mitigation Strategies
  - Identify risks associated with getting these FSW requirements implemented, tested and ready for I&T/operations. In the case of boot-up, accuracy of hardware specs. and availability of flight hardware should be discussed.

The bulleted headings are not required on the charts if not useful (e.g., Functional. Requirements. will be obvious).

CANDIDATE FSW REQUIREMENTS TOPIC ORGANIZATIONS

C&DH FSW

- Respond to CPU Power-up (Boot-up)
- Perform flight hardware diagnostics (details
- Activate FSW tasks and Provide inter-task message handling
- Provide FSW health and safety (housekeeping data, watchdog, etc.)
- Manage and distribute spacecraft time
- Activate Downlink (or spacecraft) Communications
- Generate telemetry
- Accept and distribute ground commands
- Update flight code
- Update flight data, including stored command memory
- Process Stored Command sequences
- Monitor telemetry and respond to pre-defined events
- Provide pre-defined memory contents to ground
- Monitor flight memory for SEUs, other memory violations
- Perform science instrument support (beyond data handling & cmds.)
- Store flight data for later playback to ground
- Playback flight data during ground contact
- Maximize Science Operations -- provide warm restart recovery from selected anomalies

- Restart CPU (if different from hardware boot-up or warm restart)

GN&C FSW

tbs

Instrument FSW

tbs

FSW RESOURCE UTILIZATION REQUIREMENTS

Resource goals and preliminary sizing estimates (1 chart)

- Provide resource goals and preliminary sizing estimates in the context of available hardware allocations (memory types, buses, CPU, etc.)

Measurement and Tracking Approach (1 chart)

- Explain the approach to be used to measure and track resource utilizations.

FSW QUALIFICATION REQUIREMENTS

The goal of this section is to identify the test facilities and test activities required to qualify the FSW for launch and operations. This is intended to be a fairly short, but very specific summary of the critical elements of the end-to-end FSW test program.

FSW Test Environments

- Provide comprehensive diagrams of each FSW test environment clearly identifying each relevant flight hardware element and its level of fidelity, each simulator and its level of fidelity and the ground system. Be sure to include the test environments to be used by the FSW development and test teams prior to availability of the ETU lab (e.g., commercial and/or breadboard hardware selections and fidelities).

Differences Between Test Environments and Flight Environment (1 chart)

- List each difference between a FSW test environment and the eventual flight environment (e.g., electronics, simulations, ground system, …)

Required FSW Test Activities (1 chart)

- One chart on required FSW test activities

FSW Test Activities	Test Level	Test Environment
FSW Developer Tests	Unit Test	Desktop or Target Hardware
" "	Build Integration Test	Desktop and Target Hardware
FSW Test Specialist Tests	Build Verification Test	ETU Lab
" "	System Validation Test	ETU Lab

Test level Summary(1 chart)

- One chart summarizing why the different test levels are required
- FSW Acceptance Test:
  - Occurs at the end of the FSW System Test program and consists of the execution of the full FSW System Test suite on the final FSW build using the highest fidelity FSW test environment (ETU Lab).
  - FSW AT will occur prior to the first CPT.

Sample Traceability Matrices (2 charts)

- Provide sample traceability matrix of requirements to build-level and system-level tests..

Additional Launch Qualification Tests (1 chart)

- Identify additional tests on flight hardware that further qualify the FSW for launch:

Flight Hardware-Software Tests	Interface Tests	Flight h/w
I&T Functional Tests	Functional and Performance	Flight h/w
MOC Mission Simulations	Nominal and Anomalous Ops	Flight h/w or ETU Lab

Qualification Risks and Mitigation Strategies (1 chart)

- Summarize risks and risk mitigations associated with any differences between the test facilities and the flight hardware plus on-orbit environment (simulations).

RISKS AND ISSUES

This section addresses risks, mitigation plans, and issues and concerns:

FSW Team Risks and Mitigation Plans

Identify each known or suspected risk and the approach to avoiding and/or mitigating each risk. Note the focus on mitigating risks that are not in our control however, if there are risks internal to the FSW team productivity, those risks are to be worked with FSB mgmt. to identify migitation plans – at which point the risk and mitigation plan are to be presented at the SRR.

Provide the date at which the risk becomes an impact to the FSW cost and/or schedule.

Typical risks at the time of the SRR include:

- Lingering and new FSW requirements that impact FSW design, implementation, costs, …
- FSW Testbed fidelities, number of planned testbeds, hardware delivery schedules
- Availability and completeness of flight hardware specifications
- Schedule, staffing, funds
- ICDs …

Issues and Concerns

Examples:

- FSW safing modes, safehold controllers)
- Routine health and safety checks of the flight hardware & FSW systems
- FSW safing and independent safehold modes
- Onboard diagnostics utilities to facilitate onboard anomaly investigations
- Ground visibility into all facets of FSW and flight hardware behavior
- Need for FSW techniques